

Supporting Information

Title: Organophosphate and organohalogen flame-retardant exposure and thyroid hormone disruption in a cross-sectional study of female firefighters and office workers from San Francisco.

Jessica Trowbridge^{1,2}, Roy Gerona³, Michael McMaster^{4,5}, Katherine Ona⁵, Cassidy Clarity^{1,2}, Vincent Bessonneau⁶, Ruthann Rudel⁶, Heather Buren⁷, Rachel Morello-Frosch^{1,2}

Number of pages: 27

Number of tables: 4

Number of Figures: 2

Table S1. Flame retardant compounds, their metabolites, potential sources, uses, and evidence of toxicity

Parent compound (primary)	metabolite measured	Abbr.	Potential sources	Prop 65 ^a list	Evidence of TH effects ^b
tris(2-chloroethyl) phosphate (TCEP)	bis(2-chloroethyl) phosphate	BCEP	Polyurethane foams, plastics, polyester resin and textiles ^{1,2}		
tris(1-chloro-2-propyl) phosphate (TCIPP)	bis(1-chloro-2-propyl) phosphate	BCPP	Polyurethane foams ¹		•
tris(1,3-dichloro-2-propyl) phosphate (TDCIPP)	bis(1,3-dichloro-2-propyl) phosphate	BDCPP	Plastics polyurethane foam and textiles ^{1,2}	•	•
tri-n-butyl phosphate	di-n-butyl phosphate	DBuP	Lubricants and greases, Paints and coatings ³		•
2-ethylhexyl-2,3,4,5-tetrabromobenzoate	2,3,4,5-tetrabromobenzoic acid	TBBA	Component of Firemaster® 550 ⁴ Plastics, water barriers, kitchen hoods and electronics ⁵		•
tetrabromobisphenol-A	NA	TBBPA	Reactive in circuit boards, additive in polymers, among most widely used flame retardant ⁶	•	•
tri-o-cresyl phosphate	Di-o-cresyl phosphate	DoCP	Plasticizer and flame retardant ²		•
tri-p-cresyl phosphate	Di-p_cresyl phosphate	DpCP	Plasticizer and flame retardant ⁷		
tri-benzyl phosphate	Dibenzyl phosphate	DBzP	---		

^aprop 65 <https://oehha.ca.gov/proposition-65/about-proposition-65>;

^bBoas et al, 2012; Calsolaro et al 2017; Dishaw et al 2014⁸⁻¹⁰

Table S2. Model^b results of urinary flame retardant metabolite levels and foods eaten by firefighters and office workers

Variable (times per week)	BDCPP	BCEP	DBuP
red meat	1.07 (0.97,1.19)	1.05 (0.89,1.24)	1.03 (0.91,1.16)
poultry	1.04 (0.96,1.13)	1.08 (0.93,1.26)	0.95 (0.85,1.07)
fish	0.94 (0.82,1.07)	0.79 (0.63,1.00)	0.90 (0.76,1.07)
cheese	1.00 (0.92,1.07)	0.91 (0.80,1.05)	0.89 (0.80,0.99)
milk	1.00 (0.95,1.05)	0.97 (0.89,1.07)	1.00 (0.93,1.07)
butter	1.04 (0.97,1.11)	1.02 (0.90,1.14)	1.01 (0.92,1.10)
eggs	1.01 (0.96,1.06)	1.05 (0.96,1.14)	1.00 (0.94,1.07)
ever heat food in paper package (yes)	0.51 (0.32,0.80)	0.48 (0.21,1.11)	0.88 (0.48,1.64)
eat food packaged in paper			
never	reference	reference	reference
(0.23,0.46]	0.45 (0.17,1.20)	0.52 (0.09,3.11)	2.50 (0.61,10.27)
(0.46,1]	0.68 (0.26,1.76)	1.26 (0.23,6.94)	2.85 (0.71,11.34)
(1,4]	0.75 (0.29,1.94)	1.29 (0.24,7.01)	1.81 (0.45,7.22)

^a Maximum likelihood estimation (MLE), adjusted for occupation (firefighter or office worker) and log(creatinine); Coefficients were exponentiated to give the proportional change in geometric mean (95% CI) of urinary flame retardant metabolite (ng/mL) for each unit increase, or each category increase compared to the referent, of frequency of foods consumed (times per week)

Table S3. Model results of the association between flame retardants and TSH in the full group in adjusted^a Ordinary Least Squares (OLS) regression models

	Model	β(95%CI)	Percent change (95%CI)
Full group			
	BDCPP	-0.01 (-0.11,0.1)	-0.41 (-7.32,7.02)
	BCEP	-0.07 (-0.16,0.02)	-4.66 (-10.57,1.65)
	DBuP	-0.02 (-0.14,0.11)	-1.03 (-9.04,7.67)
Firefighters			
	BDCPP	0.05 (-0.15,0.25)	3.55 (-9.88,18.97)
	BCEP	-0.13 (-0.3,0.04)	-8.42 (-18.61,3.05)
	DBuP	0.02 (-0.2,0.23)	1.26 (-12.66,17.39)
Office workers ^b			
	BDCPP	-0.02 (-0.14,0.1)	-1.49 (-9.33,7.02)

^a Models adjusted for age and log(creatinine) values below LOD replaced with LOD/sqrt(2); ^b Among office workers only BDCPP had DF >70% to use in linear models.

Table S4. Percent change (95% CI) in total T₄ for each category increase in FR compared to levels below the LOD for firefighters and office workers from adjusted OLS regression models^a.

Firefighters			Office Workers		
DBuP	N		N		
<LOD	14	reference	<LOD	57	reference
LOD-50th%	34	-6.07 (-19.45,9.53)	≥LOD	24	5.57 (-6.21,18.83)
>50th%	36	-12.68 (-24.94,1.59)			
<i>Continuous</i>	<i>84</i>	<i>-2.01 (-4.63,0.68)</i>			
BCEP					
<LOD	18	reference	<LOD	49	reference
LOD-50th %	24	8.05 (-7.78,26.60)	≥LOD	32	-1.16 (-11.59,10.49)
>50th%	42	5.23 (-8.88, 21.54)			
<i>Continuous</i>	<i>84</i>	<i>0.623 (-1.58,2.88)</i>			
TBBPA					
<LOD	45	reference	<LOD	47	reference
≥LOD	39	4.30 (-6.29,16.08)	≥LOD	34	6.28 (-4.71,18.54)
DPCP^b					
<LOD	49	reference			
≥LOD	35	-9.21 (-19.29,2.14)			

^aModels adjusted age and log(creatinine); if detection frequency (DF) < 50%, OPFR values were categorized into <LOD or ≥LOD; those FRs with a DF of at least 50% were categorized as <LOD, ≥LOD to 50th, and >50th; DBuP and BCEP DF >70%.

^b DF among office workers <25%.

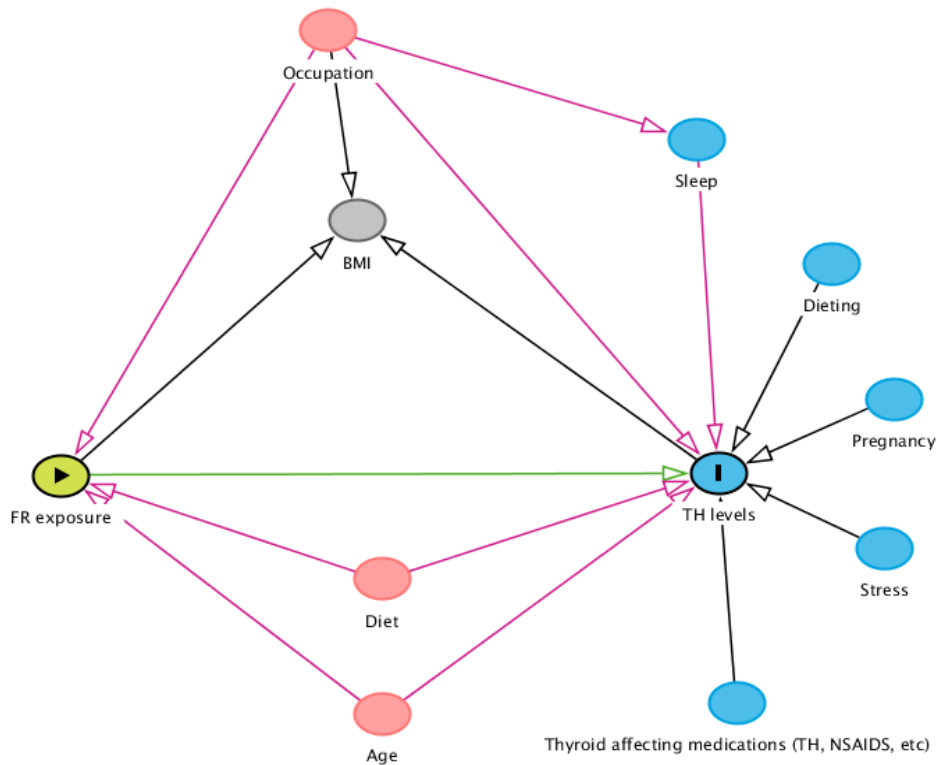


Figure S1. Directed Acyclic Graph (DAG) of the hypothesized relationship between flame retardant exposure and thyroid hormone levels.

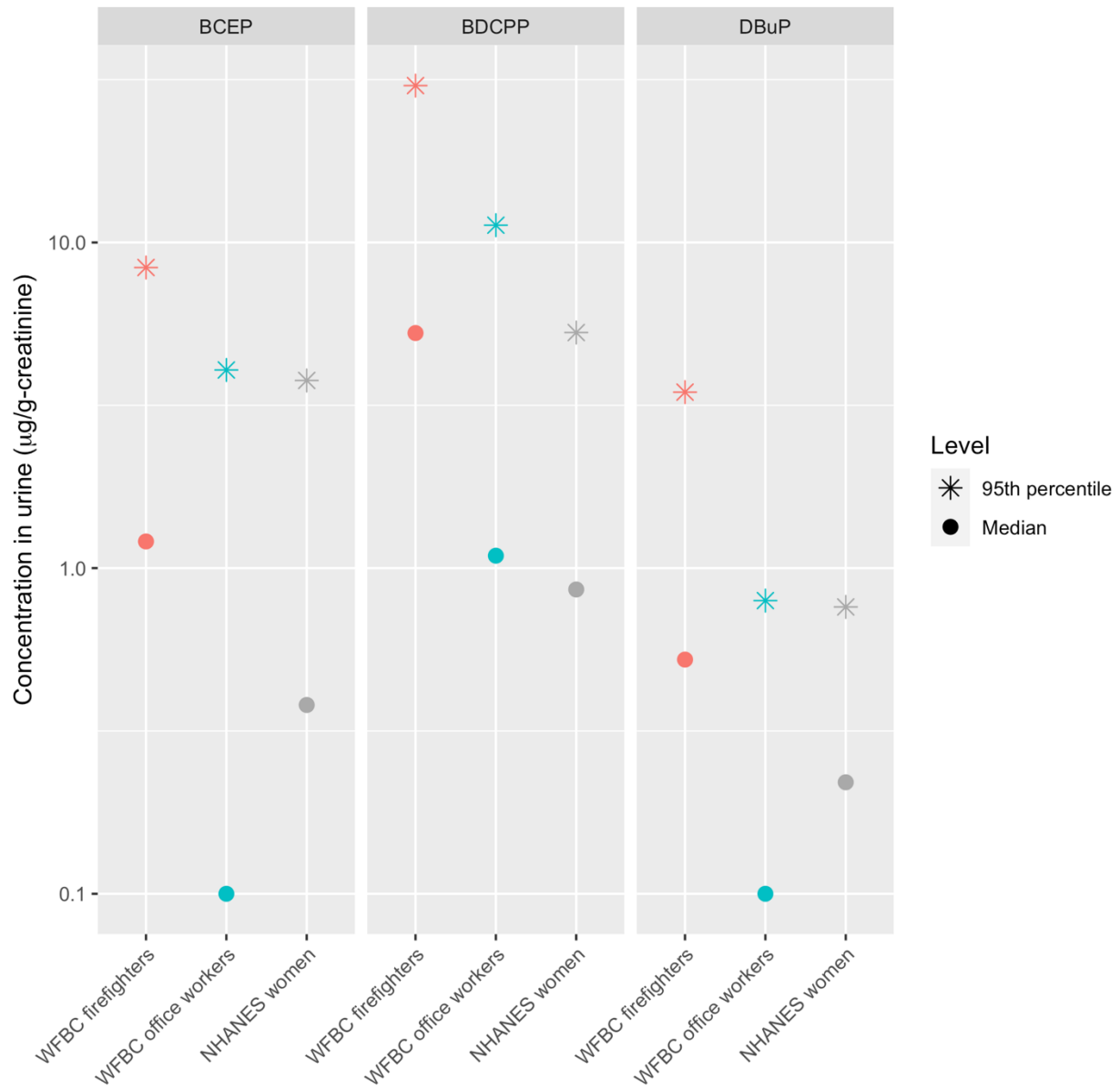


Figure S2. Median and 95th percentiles of flame retardant metabolites measured in urine (ug/g-creatinine) from 2014-2015 WFBC firefighters and office workers compared to 2013-2014 NHANES adult women (ages 18 to 65) for compounds with at least 70% DF among firefighters of the WFBC.

Additional information on laboratory methods and QA/QC for flame retardant quantification in urine

Freshly thawed urine specimens (1 mL) were deconjugated prior to LC-MS/MS analysis by addition of 450 U *H. pomatia* glucuronidase (Sigma-Aldrich, St Louis, MO) and incubated at 37 °C for two hours with constant shaking. Deconjugated urine samples were then prepared for LC-MS/MS analysis by solid phase extraction (SPE) using Waters Oasis WAX cartridges (10 mg, 30 µm, 1 cc). An Agilent ZORBAX Eclipse XDB-C8 column (2.1x100 mm, 3.5µm) maintained at 50°C was used in reversed-phase chromatography. The analytes were separated by gradient elution using water with 20 mM ammonium acetate as mobile phase A (MPA) and acetonitrile as mobile phase B (MPB). The gradient used for analyte separation consisted of 5% MPB at 0–0.5 min, gradient to 75% MPB from 0.5 to 7.5 min, gradient to 100% MBP from 7.5-9 min, 100% MPB at 9-11 min, and 5% MPB at 11.1–15 min. The analytes were ionized in the negative mode using electrospray ionization (ESI) and mass scanning was performed by multiple reaction monitoring. Each analyte was monitored using two transitions and retention time. Quantitation of each analyte was performed by isotope dilution method with their deuterated or C-13 isotopologues as internal standards.

Each of the 4 batches of samples was injected in duplicate. Procedural quality control materials and procedural blanks were run along with the calibration curve at the start, middle, and end of each run. Two QC materials were used at low (1 ng/mL of all analytes) and high (40 ng/mL of all analytes) concentrations. To accept the results of a batch run, QC materials measurements must be within 20% of their target values and the precision of their measurements have $\leq 20\%$ CV (coefficient of variation). Analyte identification from total ion chromatograms was evaluated using AB Sciex Analyst v2.1

software while quantification of each analyte was processed using AB Sciex MultiQuant v2.02 software. Analysts were blinded to firefighter and office worker status of the urine samples during the analysis.

Method Recovery and Matrix Effect

Method recovery and matrix effect for the eight analytes were assessed during method validation. To assess recovery the signals of the analytes were compared between synthetic human urine spiked with standards of the analytes before and after extraction. Matrix effect was assessed by comparing signals of the analytes obtained by spiking standards of the analytes in reconstitution solvent and synthetic human urine after extraction. Five separate replicates each of low- and high-quality control materials were used to assess both matrix effect and recovery. The average matrix effect and recovery for all QC materials used are presented in Table 1.

Recoveries for all eight analytes were observed between 88-98% alongside precision of 4.8-10.4%CV. With the exclusion of DBuP and DBzP, matrix suppression observed for the rest of the analytes was consistent with other methods reported in the literature.¹¹⁻¹³ The precision observed for all matrix effects are less than 13% CV (**Table 1**).

Table 1. Recoveries and matrix effect observed for organophosphate and organohalogen flame retardants in the validated LC-MS/MS method

Analyte	Recovery	Precision (%CV)	Matrix Effect	Precision (%CV)
bis(1,3-dichloro-2-propyl) phosphate (BDCPP)	95%	7.5	45%	10.5
bis(2-chloroethyl) phosphate (BCEP)	96%	9.3	38%	12.3
dibutyl phosphate	98%	4.8	98%	7.2

(DBuP)				
dibenzyl phosphate (DBzP)	98%	8.4	105%	5.5
di-p-cresyl phosphate (DpCP)	92%	10.4	55%	9.8
di-o-cresyl phosphate (DoCP)	93%	9.1	54%	10.5
2,3,4,5-tetrabromobenzoic acid (TBBA)	94%	7.2	41%	8.5
tetrabromobisphenol a (TBBPA)	88%	9.5	65%	11.4

Select questions from study questionnaire

BASIC WORK INFORMATION

A.1. How long have you worked as a paid firefighter for the San Francisco Fire Department?

Years _____ [FILL IN]

DK97

Ref.98

Missing99

A.2. What month and year did you first start working as a firefighter with the San Francisco Fire Department?

Month and Year _____ [FILL IN]

DK97

Ref.98

Missing99

A.3. What is your current position?

Officer1

Driver2

FF/EMT3

FF/PM.....4

Tiller.....5

FF6

Unassigned/VR.....7

Swing (specify)_____	8
DK.....	97
Ref.....	98
Missing	99

A.4. What is your current rank?

H2.....	1
H3.....	2
H6.....	3
H10.....	4
H20.....	5
H24 (Officer, Fire Investigation)	6
H30.....	7
H40.....	8
DK.....	97
Ref.....	98
Missing	99

Section B. WORK ACTIVITIES HISTORY

The next questions are about your activities in the 24 hours prior to completing this survey. These questions are only about your most recent potential exposures.

B.1. Are you currently:	
<input type="checkbox"/>	On Duty, and have been for less than 8 hours
<input type="checkbox"/>	On Duty, and have been between 8-24 hours
<input type="checkbox"/>	On Duty, and have been for more than 24 hours [GO TO B.3]
<input type="checkbox"/>	Off Duty, and have been for less than 24 hours
<input type="checkbox"/>	Off Duty, and have been for 24 hours or more
<input type="checkbox"/>	DK
<input type="checkbox"/>	Refused
In the past <u>24 hours</u> , how many hours did you spend:	
B.2. <i>Off Duty Activities</i>	
A. Indoors (including time spent sleeping)	_____ Hours
.....	
B. In a car or vehicle (not a Fire Department vehicle).....	_____ Hours
C. Outdoors.....	_____ Hours
D. Other (please specify):	_____ Hours

B.3. <i>On Duty Activities</i>	

A. At a fire station in quarters (including time spent sleeping)	_____ Hours
B. In a Fire Department vehicle.....	_____ Hours
C. On an incident call or training	_____ Hours
Type of incident?	
<input type="checkbox"/> Hazardous material spill (not fire)	
<input type="checkbox"/> Commercial fires	
<input type="checkbox"/> Industrial fires	
<input type="checkbox"/> House fires/residential fires	
<input type="checkbox"/> Vehicular/car fires	
<input type="checkbox"/> Vegetation/brush fires	
<input type="checkbox"/> Trash/dumpster fire	
<input type="checkbox"/> Electrical/transformer fire	
<input type="checkbox"/> Fire watch	
<input type="checkbox"/> Training (fire ground operations)	
<input type="checkbox"/> Medical aid	
<input type="checkbox"/> Motor vehicle accident	
<input type="checkbox"/> Building alarm investigation—system malfunction	
<input type="checkbox"/> Building alarm investigation—gas or smoke detected	
<input type="checkbox"/> Investigation of odors or smoke—no merit	
<input type="checkbox"/> Investigation of odors or smoke—odor detected	
<input type="checkbox"/> Other (please specify): _____	
<input type="checkbox"/> <i>DK</i>	
<input type="checkbox"/> <i>Refused</i>	
D. Other (please specify): _____	_____ Hours
B.4. Total [Verify that total hours equal 24 hours.].....	_____ Hours

These next questions are about your activities and incidents in the last month.

B.5. During the last month, so since _____ [FILL IN WITH DATE 1 MONTH PRIOR TO INTERVIEW], have you participated in any fire response or fire response training activities involving live fires?

No.....0
Yes1
DK.....97
Ref.....98
Missing99

B.5.a [If YES] Please describe the activities and how many total hours did you spend at these fires?

These next questions refer to your usual work practices in the past year. The response options are **Never, Rarely, Sometimes, Often** or **Always**

B.6. During exterior fire suppression activities, how often do you wear your SCBA (self-contained breathing apparatus)?

- Never 1
- Rarely 2
- Sometimes..... 3
- Often 4
- Always 5
- I do not participate in exterior fire suppression 6
- DK* 97
- Ref*..... 98
- Missing 99

B.7. During interior fire suppression activities, how often do you wear your SCBA (self-contained breathing apparatus)?

- Never 1
- Rarely 2
- Sometimes..... 3
- Often 4
- Always 5
- I do not participate in interior fire suppression 6
- DK* 97
- Ref*..... 98
- Missing 99

B.8. During ventilation activities, how often do you wear your SCBA (self-contained breathing apparatus)?

- Never 1
- Rarely 2
- Sometimes..... 3
- Often 4
- Always 5
- I do not participate in ventilation activities 6
- DK* 97
- Ref*..... 98
- Missing 99

No.....0
 Yes.....1
 DK.....97
 Ref.....98
 Missing.....99

B.13. Have you participated in cleaning or polishing the fire truck and/or other firehouse vehicles IN THE LAST MONTH?

No.....0
 Yes.....1(go to B.17.a)
 DK.....97
 Ref.....98
 Missing.....99

B.17.a Have you participated in cleaning or polishing the fire truck and/or other firehouse vehicles IN LAST 24 HOURS?

No.....0
 Yes.....1
 DK.....97
 Ref.....98
 Missing.....99

Other questions:

Section F. – OFFICE WORKER WORK ACTIVITIES HISTORY

The next questions are about your work and exposures that you might experience while at your job.

F.1. How many hours a day do you use a computer?

Hours/day
 DK..... 97
 Ref..... 98
 Missing..... 99

F.2. How many hours a day do you sit on furniture that contains foam?

Hours/day
 DK..... 97
 Ref..... 98
 Missing..... 99

F.3. Is the upholstery fabric on the foam furniture ripped?

No.....0
Yes.....1
DK.....97
Ref.....98
Missing.....99

F.4. Is there a tag on any of your office furniture stating that the furniture meets California fire standards? (Tag may refer to TB117 standard and will be on the underside of the chair, couch, etc.)

No.....0
Yes.....1
DK.....97
Ref.....98
Missing.....99

F.5. Is your office carpeted?

No.....0
Yes.....1
DK.....97
Ref.....98
Missing.....99

- F.6.** Do your office windows have curtains?
- No.....0
Yes.....1
DK.....97
Ref.....98
Missing.....99
- F.7.** Have your office furniture, carpet or curtains been treated with stain or water repellent?
- No.....0
Yes.....1
DK.....97
Ref.....98
Missing.....99
- F.8.** Do your windows open?
- No.....0
Yes.....1
DK.....97
Ref.....98
Missing.....99
- F.9.** How often is your office vacuumed?
- Never 1
Rarely 2
Every week 3
Every two or three weeks 4
Every month 5
DK..... 97
Ref..... 98
Missing..... 99

Everyone Asked

Section K. FOOD AND FOOD PREPARATON

I am going to ask you about many foods. Please tell me how many times a day, week, month or year you eat each food item.

Food	Frequency
K.1. Red meat (for example, beef, pork, lamb or goat)	__ __ times per: r day r week r month r year r Never r DK r Refused
K.2. Poultry (for example, chicken, turkey or duck)	__ __ times per: r day r week r month r year r Never r DK r Refused
K.3. Grilled, smoked or barbecued meats	__ __ times per: r day r week r month r year r Never r DK r Refused
K.4. Grilled, smoked or barbecued vegetables	__ __ times per: r day r week r month r year r Never r DK r Refused
K.5. Liver, liver pate, liverwurst or any other kind of liver dish	__ __ times per: r day r week r month r year r Never r DK r Refused
K.6. Fish from stores, markets or restaurants. This includes any fish that is fresh, frozen, smoked, dried, or canned, such as canned tuna or sardines.	__ __ times per: r day r week r month r year r Never r DK r Refused
K.7. Fish caught by you or someone you know. Please do not include fish that came from stores, markets, or restaurants	__ __ times per: r day r week r month r year r Never r DK r Refused
K.8. Shellfish from stores, markets or restaurants. This includes any shellfish, like shrimp, that is fresh, frozen, smoked, dried, or canned, such as canned clams or mussels.	__ __ times per: r day r week r month r year r Never r DK r Refused
K.9. Shellfish caught by you or someone you know. Please do not include shellfish that came from stores, markets, or restaurants.	__ __ times per: r day r week r month r year r Never r DK r Refused

Food	Frequency
K.10.Eggs	_ _ times per: r day r week r month r year r Never r DK r Refused
K.11.Soy milk	_ _ times per: r day r week r month r year r Never r DK r Refused
K.12.Milk	_ _ times per: r day r week r month r year r Never r DK r Refused
K.13.What kind of milk?	r Whole (4%) r 2% Low-fat r 1% Low-fat r Non-fat r Never r DK r Refused
K.14.Cheese	_ _ times per: r day r week r month r year r Never r DK r Refused
K.15.Yogurt (including frozen yogurt)	_ _ times per: r day r week r month r year r Never r DK r Refused
K.16.What kind of yogurt?	r Whole (4%) r 2% Low-fat r 1% Low-fat r Non-fat r Never r DK r Refused
K.17. Ice Cream (not including popsicles)	_ _ times per: r day r week r month r year r Never r DK r Refused
K.18. Butter (either on food or for cooking or baking)	_ _ times per: r day r week r month r year r Never r DK r Refused
K.19.Lard (either for cooking or on food)	_ _ times per: r day r week r month r year r Never r DK r Refused
K.20.Margarine (either on food or for cooking or baking)	_ _ times per: r day r week r month r year r Never r DK r Refused
K.21.Vegetable oil (for example canola, corn, vegetable, safflower. olive) either on food or for cooking or baking	_ _ times per: r day r week r month r year r Never r DK r Refused

Food	Frequency
Snacks	
K.22.Potato chips	__ __ times per: r day r week r month r year r Never r DK r Refused
K.23.Other chips and snacks (tortilla chips, corn chips, cheese puffs, nuts, etc.)	__ __ times per: r day r week r month r year r Never r DK r Refused
K.24.Microwave popcorn	__ __ times per: r day r week r month r year r Never r DK r Refused
K.25.Movie theater popcorn	__ __ times per: r day r week r month r year r Never r DK r Refused
K.26.Sweets (cake, cookies, candy, chocolate)	__ __ times per: r day r week r month r year r Never r DK r Refused
K.27.Fast Food and Take-Out Food	__ __ times per: r day r week r month r year r Never r DK r Refused
K.28.Take-out or delivered pizza	__ __ times per: r day r week r month r year r Never r DK r Refused
K.29.Food from a restaurant that is wrapped in paper or packaged in a cardboard container (for example hamburgers, sandwiches, burritos, Chinese food)	__ __ times per: r day r week r month r year r Never r DK r Refused
K.30.French fries (either from a take-out or to-go restaurant)	__ __ times per: r day r week r month r year r Never r DK r Refused
K.31.Food from a store that comes in a paper or cardboard package and that you heat in the package, such as pizza, frozen meals, and garlic bread [show cue cards]	__ __ times per: r day r week r month r year r Never r DK r Refused r Did not heat food in container

K.32. How often do you open a window or use a fan over your kitchen stove when you cook on your stove?

Never	1
Rarely	2
Sometimes	3
Often	4
Always.....	5
<i>DK</i>	97
<i>Ref</i>	98
Missing.....	99

The next questions I'm going to ask you are about non-stick or Teflon cookware and plastics.

Here are some pictures of non-stick or Teflon cookware. Non-stick coatings are smooth and usually black or gray.

K.33. How many non-stick or Teflon pots, pans or baking dishes do you use?

|__| |__|

None 0
DK..... 97
Ref..... 98
Missing..... 99

K.34. How many of these non-stick pans and pots are scratched?

|__| |__|

None 0
DK..... 97
Ref..... 98
Missing..... 99

K.35. How many times per day, week or month do you use your non-stick pans, pots or bake ware in the oven or broiler?

|__| |__| per day week month

None 0
DK..... 97
Ref..... 98
Missing..... 99

K.36. Do you pre-heat your non-stick pans, pots or bake ware without food or oil in them?

No 0
Yes..... 1
DK..... 97
Ref..... 98
Missing..... 99

K.37. Do you store food in plastic containers or with plastic wrap?

No 0
Yes..... 1
DK..... 97
Ref..... 98
Missing..... 99

K.38. Do you reheat food in plastic containers or with plastic wrap?

No 0

Yes..... 1
 DK..... 97
 Ref..... 98
 Missing..... 99

I) For questions K.39 – K.43, show **Non-stick Cue Cards** again, pointing to each item you ask about.

Do you have a ... [FILL IN]		A. How often do you use it?	B. How old is it?	C. Does [ITEM] have any scratches?	D. Do you wash the [ITEM] in the dishwasher?
K.39. rice cooker with a <u>non-stick bowl</u>	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> DK <input type="checkbox"/> Refused	<input type="checkbox"/> ___ ___ ___ times <input type="checkbox"/> Day <input type="checkbox"/> Week <input type="checkbox"/> Month <input type="checkbox"/> Year <input type="checkbox"/> Never <input type="checkbox"/> DK <input type="checkbox"/> Refused	<input type="checkbox"/> < 1 year <input type="checkbox"/> 1-2 years <input type="checkbox"/> 3-5 years <input type="checkbox"/> >5 years	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> DK <input type="checkbox"/> Refused	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> DK <input type="checkbox"/> Refused
K.40. non-stick electric grill or fry pan (like a George Foreman grill)	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> DK <input type="checkbox"/> Refused	<input type="checkbox"/> ___ ___ ___ times <input type="checkbox"/> Day <input type="checkbox"/> Week <input type="checkbox"/> Month <input type="checkbox"/> Year <input type="checkbox"/> Never <input type="checkbox"/> DK <input type="checkbox"/> Refused	<input type="checkbox"/> < 1 year <input type="checkbox"/> 1-2 years <input type="checkbox"/> 3-5 years <input type="checkbox"/> >5 years	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> DK <input type="checkbox"/> Refused	<input type="checkbox"/> _ Skip this question
K.41. non-stick grilled sandwich maker <input type="checkbox"/> or quesadilla maker	<input type="checkbox"/> Yes-sandwich <input type="checkbox"/> Yes-quesadilla <input type="checkbox"/> No <input type="checkbox"/> DK <input type="checkbox"/> Refused	<input type="checkbox"/> ___ ___ ___ times <input type="checkbox"/> Day <input type="checkbox"/> Week <input type="checkbox"/> Month <input type="checkbox"/> Year <input type="checkbox"/> Never <input type="checkbox"/> DK <input type="checkbox"/> Refused	<input type="checkbox"/> < 1 year <input type="checkbox"/> 1-2 years <input type="checkbox"/> 3-5 years <input type="checkbox"/> >5 years	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> DK <input type="checkbox"/> Refused	<input type="checkbox"/> _ Skip this question

Do you have a ... [FILL IN]		A. How often do you use it?	B. How old is it?	C. Does [ITEM] have any scratches?	D. Do you wash the [ITEM] in the dishwasher?
K.42. non-stick waffle iron	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> DK <input type="checkbox"/> Refused	<input type="checkbox"/> ___ ___ ___ times <input type="checkbox"/> Day <input type="checkbox"/> Week <input type="checkbox"/> Month <input type="checkbox"/> Year <input type="checkbox"/> Never <input type="checkbox"/> DK <input type="checkbox"/> Refused	<input type="checkbox"/> < 1 year <input type="checkbox"/> 1-2 years <input type="checkbox"/> 3-5 years <input type="checkbox"/> >5 years	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> DK <input type="checkbox"/> Refused	<input type="checkbox"/> _ Skip this question
K.43. bread maker with a <u>non-stick bowl</u>	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> DK <input type="checkbox"/> Refused	<input type="checkbox"/> ___ ___ ___ times <input type="checkbox"/> Day <input type="checkbox"/> Week <input type="checkbox"/> Month <input type="checkbox"/> Year <input type="checkbox"/> Never <input type="checkbox"/> DK <input type="checkbox"/> Refused	<input type="checkbox"/> < 1 year <input type="checkbox"/> 1-2 years <input type="checkbox"/> 3-5 years <input type="checkbox"/> >5 years	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> DK <input type="checkbox"/> Refused	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> DK <input type="checkbox"/> Refused

Section M. YOUR HOME

The next questions are about household products you may have used in your home in the past 3 months.

In the past 3 months, have you used any ... in your home?		A. Did you use... in the last 24 hours?	B. Was ... scented?
M.1. Cleaning solvents such as stain removers, degreasers, and oven cleaners	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> DK <input type="checkbox"/> Refused	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> DK <input type="checkbox"/> Refused	<input type="checkbox"/> Skip this question
M.2. Antibacterial soaps or cleaners (other than hand and body soaps)	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> DK <input type="checkbox"/> Refused	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> DK <input type="checkbox"/> Refused	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> DK <input type="checkbox"/> Refused

M.3. Household cleaners such as kitchen or bathroom cleaners	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> DK <input type="checkbox"/> Refused	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> DK <input type="checkbox"/> Refused	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> DK <input type="checkbox"/> Refused
M.4. Floor or furniture polish or wax	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> DK <input type="checkbox"/> Refused	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> DK <input type="checkbox"/> Refused	<input type="checkbox"/> Skip this question
M.5. Air fresheners such as plug ins or sprays	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> DK <input type="checkbox"/> Refused	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> DK <input type="checkbox"/> Refused	<input type="checkbox"/> Skip this question
M.6. Scented candles or incense	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> DK <input type="checkbox"/> Refused	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> DK <input type="checkbox"/> Refused	<input type="checkbox"/> Skip this question

Now I'm going to ask you about any building repair or remodeling work that has been done in the past year inside or outside your home.

In the past year have you...		Did you or someone else do the work?
M.7. Treated any furniture, carpets or mattresses to be stain or water-resistant?	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> DK <input type="checkbox"/> Refused	<input type="checkbox"/> Participant <input type="checkbox"/> Someone else <input type="checkbox"/> Both <input type="checkbox"/> DK <input type="checkbox"/> Refused
M.8. Removed or installed any carpets	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> DK <input type="checkbox"/> Refused	<input type="checkbox"/> Participant <input type="checkbox"/> Someone else <input type="checkbox"/> Both <input type="checkbox"/> DK <input type="checkbox"/> Refused
M.8.1. [If R. reports carpet work] Do you have recycled foam under your carpets? <input type="checkbox"/> CUE CARD of recycled foam	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> DK <input type="checkbox"/> Refused	<input type="checkbox"/> _ Skip this question
M.9. Had any furniture (tables, chairs, sofas, cabinets, bookshelves, dressers) reupholstered (covered with fabric, replacing cushions)	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> DK <input type="checkbox"/> Refused	<input type="checkbox"/> Participant <input type="checkbox"/> Someone else <input type="checkbox"/> Both <input type="checkbox"/> DK <input type="checkbox"/> Refused
M.10. Done any electronics repair, manufacturing, or recycling	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> DK <input type="checkbox"/> Refused	<input type="checkbox"/> Participant <input type="checkbox"/> Someone else <input type="checkbox"/> Both <input type="checkbox"/> DK <input type="checkbox"/> Refused
M.11. Done any other home improvement work: _____	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> DK <input type="checkbox"/> Refused	<input type="checkbox"/> Participant <input type="checkbox"/> Someone else <input type="checkbox"/> Both <input type="checkbox"/> DK <input type="checkbox"/> Refused

Health and medication QUESTIONS

These next questions are about whether or not you take birth control or other hormone supplements.

Q.1. Are you currently taking any form of hormonal birth control? For example, daily pill, injectable, such as Depo-Provera, implant, such as Norplant, or other form of hormonal birth control?

No.....0 [GO TO

Q.2.]

Yes (I take) [SKIP TO

Q.3.]

Daily Pill 1

Injectable 2

Implant 3

Other [Fill in]_____

DK.....97

Ref.....98

Missing99

Q.1.a. [If NO from Q.1.] If not currently taking anything, did you ever take any form of hormonal birth control?

No.....0

Yes 1

DK.....97

Ref.....98

Missing99

Q.1.a. Cont. If yes [to Q.1.a.], when was the last time you took such birth control?

Month and Year_____

DK.....97

Ref.....98

Missing99

Q.2. Do you take any hormones other than birth control (such as Premarin)? If yes, what do you take?

No.....0

Yes [fill in]_____..1

DK.....97

Ref.....98

Missing99

Q.3. [If NO from Q.2.] If not currently taking anything, did you ever take any hormone products (other than birth control)? If yes, what? and how many years and months ago did you take such hormone products?

No.....0

Yes1

Name of Product_____

_____ Years & _____ Months Ago

DK.....97

Ref.....98
Missing99

Q.4. What was the date of your last menstrual period? [Show calendar to participant]

Day, month, year: _____ 1

I no longer have periods2

DK.....97

Ref.....98

Missing99

Q.5. If you no longer have periods, about how old were you when you went through menopause?

Age [in years]_____ 1

DK.....97

Ref.....98

Missing99

Bibliography for supporting information

- (1) Van den Eede, N.; Dirtu, A. C.; Ali, N.; Neels, H.; Covaci, A. Multi-Residue Method for the Determination of Brominated and Organophosphate Flame Retardants in Indoor Dust. *Talanta* **2012**, *89*, 292–300. <https://doi.org/10.1016/j.talanta.2011.12.031>.
- (2) van der Veen, I.; de Boer, J. Phosphorus Flame Retardants: Properties, Production, Environmental Occurrence, Toxicity and Analysis. *Chemosphere* **2012**, *88* (10), 1119–1153. <https://doi.org/10.1016/j.chemosphere.2012.03.067>.
- (3) Schindler, B. K.; Weiss, T.; Schütze, A.; Koslitz, S.; Broding, H. C.; Bünger, J.; Brüning, T. Occupational Exposure of Air Crews to Tricresyl Phosphate Isomers and Organophosphate Flame Retardants after Fume Events. *Arch Toxicol* **2013**, *87* (4), 645–648. <https://doi.org/10.1007/s00204-012-0978-0>.
- (4) Hoffman, K.; Fang, M.; Horman, B.; Patisaul, H. B.; Garantziotis, S.; Birnbaum, L. S.; Stapleton, H. M. Urinary Tetrabromobenzoic Acid (TBBA) as a Biomarker of Exposure to the Flame Retardant Mixture Firemaster® 550. *Environ. Health Perspect.* **2014**, *122* (9), 963–969. <https://doi.org/10.1289/ehp.1308028>.
- (5) Covaci, A.; Harrad, S.; Abdallah, M. A.-E.; Ali, N.; Law, R. J.; Herzke, D.; de Wit, C. A. Novel Brominated Flame Retardants: A Review of Their Analysis, Environmental Fate and Behaviour. *Environment International* **2011**, *37* (2), 532–556. <https://doi.org/10.1016/j.envint.2010.11.007>.
- (6) Birnbaum, L. S.; Staskal, D. F. Brominated Flame Retardants: Cause for Concern? *Environ. Health Perspect.* **2004**, *112* (1), 9–17. <https://doi.org/10.1289/ehp.6559>.
- (7) van der Veen, I.; de Boer, J. Phosphorus Flame Retardants: Properties, Production, Environmental Occurrence, Toxicity and Analysis. *Chemosphere* **2012**, *88* (10), 1119–1153. <https://doi.org/10.1016/j.chemosphere.2012.03.067>.
- (8) Boas, M.; Feldt-Rasmussen, U.; Main, K. M. Thyroid Effects of Endocrine Disrupting Chemicals. *Mol. Cell. Endocrinol.* **2012**, *355* (2), 240–248. <https://doi.org/10.1016/j.mce.2011.09.005>.
- (9) Calsolaro, V.; Pasqualetti, G.; Niccolai, F.; Caraccio, N.; Monzani, F. Thyroid Disrupting Chemicals. *Int J Mol Sci* **2017**, *18* (12). <https://doi.org/10.3390/ijms18122583>.
- (10) Dishaw, L. V.; Macaulay, L. J.; Roberts, S. C.; Stapleton, H. M. Exposures, Mechanisms, and Impacts of Endocrine-Active Flame Retardants. *Curr Opin Pharmacol* **2014**, *19*, 125–133. <https://doi.org/10.1016/j.coph.2014.09.018>.
- (11) Castro, V.; Montes, R.; Quintana, J. B.; Rodil, R.; Cela, R. Determination of 18 Organophosphorus Flame Retardants/Plasticizers in Mussel Samples by Matrix Solid-Phase Dispersion Combined to Liquid Chromatography-Tandem Mass Spectrometry. *Talanta* **2020**, *208*, 120470. <https://doi.org/10.1016/j.talanta.2019.120470>.
- (12) Bastiaensen, M.; Xu, F.; Been, F.; Van den Eede, N.; Covaci, A. Simultaneous Determination of 14 Urinary Biomarkers of Exposure to Organophosphate Flame Retardants and Plasticizers by LC-MS/MS. *Anal Bioanal Chem* **2018**, *410* (30), 7871–7880. <https://doi.org/10.1007/s00216-018-1402-2>.

- (13) Krystek, P.; Beeltje, H.; Noteboom, M.; van den Hoeven, E. M.; Houtzager, M. M. G. Analytical Human Biomonitoring Method for the Identification and Quantification of the Metabolite BDCPP Originated from the Organophosphate Flame Retardant TDCPP in Urine. *J Pharm Biomed Anal* **2019**, *170*, 169–175. <https://doi.org/10.1016/j.jpba.2019.03.036>.